

25 January 1971

Materiel Test Procedure 7-3-051
US Army Aviation Test Board

US ARMY TEST AND EVALUATION COMMAND
COMMODITY SERVICE TEST PROCEDURE

ENVIRONMENTAL CONTROL UNIT (ECU)

AD719101

1. OBJECTIVE

This document provides existing test methods and techniques necessary to determine the degree to which environmental control units (ECU) and their auxiliary equipment and associated tools and test equipment (maintenance package) meet the requirements stated in Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), or Technical Characteristics (TC), and whether or not the system is suitable for Army use.

2. BACKGROUND

Aircraft and crew are subjected to rapid and varying degrees of environmental change concurrent with each different phase of flight encountered. On the ground, the aircraft operating environment is determined by the climatic conditions existing at the airfield in use. In the air, at low altitudes, the environment is dependent on slightly modified local climatic conditions but changes rapidly to dependency on altitude alone as the aircraft increases in height above the frictional level of the earth's atmosphere. To cope with this problem, environmental control units (ECUs) have been developed to reduce environmental stress to a level tolerable by equipment and personnel thus providing conditions under which aircraft can be safely and efficiently operated. The ECU (a combination of ventilation, heating, moisture and contamination control, cooling and pressurization, as may be applicable) can be operated either manually or automatically and may or may not include pressurization and cooling features dependent upon the altitude ceiling and purpose of the aircraft involved. New changes in aircraft configuration and tactical operations result in the need for new development or modification of existing ECU's in order to support military aviation requirements for aircraft to function under all environmental conditions expected during their life cycle. ECU's developed as a result of these changes require a period of service testing to determine their suitability for use in Army aircraft.

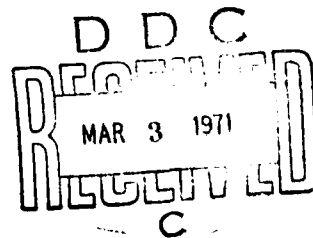
3. REQUIRED SUPPORT

3.1 FACILITIES

- a. Suitable operational airfield.
- b. Air space to conduct tests.

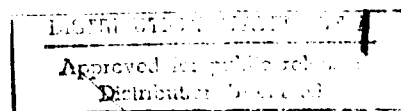
3.2 EQUIPMENT

- a. Measuring tools for determining system dimensions and weight.
- b. Temperature and pressure indicating devices.
- c. Photographic equipment.



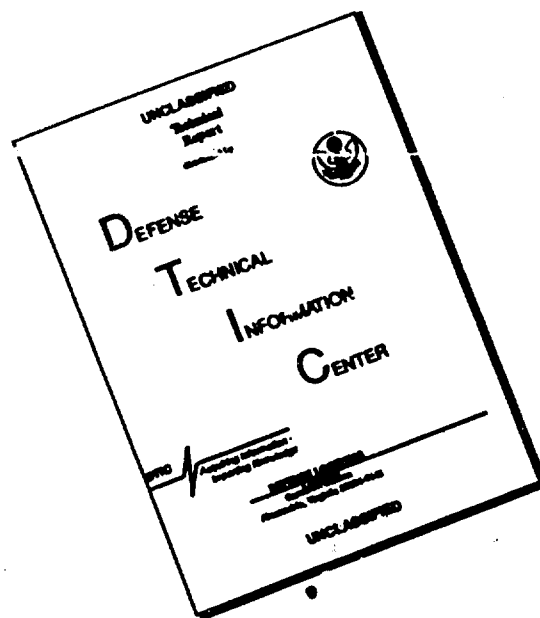
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- d. Air flow indicator.
- e. Appropriate number and types of test bed aircraft.
- f. Air contamination measuring device.
- g. Avionics and electronic maintenance support -- as required.
- h. Equipment required by referenced MTP's.

3.3 PERSONNEL

Personnel in appropriate numbers, of the proper MOS and with special training as required.

4. REFERENCES

- A. Army Regulation 385-16 Safety: Safety for Systems, Associated Subsystems, and Equipment.
- B. Army Regulation 750-6 Maintenance of Supplies and Equipment: Maintenance Support Planning.
- C. USATECOM Regulation 70-23 Research and Development: Equipment Performance Reports (EPRs).
- D. USATECOM Regulation 70-24 Research and Development: Documenting Test Plans and Reports.
- E. USATECOM Regulation 108-1 Photographic Coverage. (As implemented by USAAVNTBD Memo 108-1.
- F. USATECOM Regulation 385-6 Safety: Verification of Safety of Materiel During Testing.
- G. USATECOM Regulation 700-1 Quality Assurance: Value Engineering.
- H. USATECOM Regulation 750-15 Maintenance of Supplies and Equipment: Maintenance Evaluation During Testing.
- I. MIL-STD-129 Marking for Shipment and Storage.
- J. MIL-STD-130 Identification Marking of US Military Property.
- K. MIL-STD-882 System Safety Program for Systems and Associated Subsystems and Equipment: Requirements for.
- L. MIL-E-38453 Environmental Control, Environmental Protection, and Engine Bleed Air Systems, Aircraft and Aircraft Launched Missiles, General Specification for.
- M. MTP 6-3-501, Pre-Test Inspection for Service Test.
- N. MTP 6-3-502, Personnel Training Requirements.
- O. MTP 6-3-506, Durability.
- P. MTP 6-3-509, Effects of Weather.
- Q. MTP 6-3-517, Electrical Power Requirements.
- R. MTP 7-3-500, Physical Characteristics.
- S. MTP 7-3-502, Installation Characteristics.
- T. MTP 7-3-506, Safety.
- U. MTP 7-3-507, Maintenance (Maintainability/Availability).
- V. MTP 7-3-508, Reliability.
- W. MTP 7-3-509, Compatibility with Related Equipment.
- X. MTP 7-3-510, Human Factors.
- Y. MTP 7-3-514, Adequacy of Technical Manuals.
- Z. MTP 7-3-519, Photographic Coverage.
- AA. QMR, SDR or TC for environmental control unit.

5. SCOPE

5.1 SUMMARY

This materiel test procedure describes tests for evaluating environmental control units provided as auxiliary aircraft equipment. Tests will be conducted using aircraft equipped with environmental control units to determine if the compartment environment can be maintained at levels sufficient to provide conditions for safe and efficient operation of the aircraft. Aircraft and equipment will be operated and maintained by test personnel representative of those skills normally assigned to such duties. The suitability of the environmental control unit will be evaluated against the requirements of applicable QMR, SDR, TC or other approved documents.

5.1.1 Preparation for Test

This section provides guidance for test project planning to determine facility and equipment requirements, and instructions for test personnel familiarization.

5.1.2 Test Conduct

The tests and evaluations are arranged in a logical sequence to provide a step-by-step analysis of the suitability of the environmental control unit to perform its prime functions of providing conditions for safe and efficient operation of the aircraft. The specific tests to be performed, and their intended objectives, are listed below:

a. Initial Inspection -- To determine the receipt of an aircraft with a complete or a minimum configuration environmental control unit and its condition upon arrival.

b. Installation characteristics -- To determine the ease of installation and removal of the environmental control unit, if applicable.

c. Power Requirements -- To determine the adequacy of the power sources to meet the requirements for operation of the environmental control unit.

d. Operational Performance -- To determine the adequacy and suitability of the environmental control unit to provide ventilation, heating, moisture and contamination control, cooling and pressurization, as may be applicable, in accordance with the requirements of applicable QMR, SDR, TC or other approved documents.

e. Compatibility with Related Equipment -- To determine the suitability of the environmental control unit for operation with related equipment in various configurations.

f. Durability -- To evaluate the time in service, failure potential of components and durability of the environmental control unit during operation.

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g. Effects of Weather -- To determine the capabilities and limitations imposed upon the operation of the environmental control unit due to the extremes of weather.

h. Maintenance Evaluation -- To determine the maintenance/maintainability requirements of the environmental control unit and determine the adequacy of the maintenance test package (tools and test equipment, equipment technical manuals, and repair parts).

i. Maintainability -- An evaluation to determine adequacy of design characteristics which is expressed as the probability that an item will be retained in or restored to a specific condition within a given period of time, when maintenance is performed in accordance with prescribed procedures and resources.

j. Reliability -- An evaluation to determine the probability that the test item will perform its intended function for a specified interval under stated conditions.

k. Achieved Availability -- To evaluate the probability that the environmental control unit, when used under stated conditions in an ideal support environment (total availability of tools, parts, manpower, manuals, etc.), shall operate satisfactorily at any given time.

l. Safety -- An evaluation to identify and examine hazardous characteristics of the design and operating procedures of the environmental control units.

m. Human Factors -- To determine if the environmental control unit is designed so as to comply with accepted human factors engineering principles.

n. Personnel Training Requirements -- To determine the scope and effectiveness of pretest training associated with operating and maintaining the environmental control unit and the need for additional training.

5.1.3 Test Data

This section details the data to be collected and recorded while completing the test procedures in section 6.2, Test Conduct.

5.1.4 Data Reduction and Presentation

This section provides instructions for evaluating and displaying the data recorded during testing.

5.2 LIMITATIONS

None.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Test Planning

Formulate a plan of test utilizing reference 4.D and the following general procedures:

a. Review --

- 1) The test directive.
- 2) QMR, SDR and TC.
- 3) Other applicable sources of criteria.
- 4) Instructional material available from the manufacturer.
- 5) All reports of previous tests conducted on like types of equipment.

b. Prepare a detailed test schedule showing proposed time periods allotted for each test listed in paragraph 5.1.2. Ensure that a sufficient number of samples of all measurements are taken to provide statistical confidence in the final data.

c. Prepare necessary forms for entry of test data.

d. Determine adequate safety measures necessary to provide safety for personnel and equipment, and ensure that these measures are observed throughout the test. Safety release or confirmation will be obtained in accordance with ref 4.F.

e. Plan to utilize photographic techniques where possible to record and document findings and results of testing. (See reference 4.E.)

6.1.2 Required Support

a. Review the support requirements of section 3.

b. Select and schedule suitable transportation and operational areas at representative locations. Ensure availability of maintenance support facilities, special test equipment, repair parts, and personnel.

c. Ensure that all support aircraft have been scheduled as required and that arrangements for supporting and participating agencies, activities, and facilities have been made.

6.1.3 Personnel

Ensure that service personnel, with the appropriate MOS and skill levels for the operation and maintenance of environmental control units

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are adequately trained as prescribed in reference 4.N. Include the following:

- a. Procedures to be followed and the data to be collected during test conduct.
- b. Known hazards and safety precautions associated with the test procedures, test equipment, and environmental control units.

6.2 TEST CONDUCT

NOTE: Subtests shall be conducted concurrently with, or in conjunction with other subtests, whenever possible, so that the time needed to collect the required data will be minimized.

6.2.1 Initial Inspection

6.2.1.1 Visual Inspection

Perform the following:

a. An inventory check against the Basic Issue Item List (BIIL). Submit an Equipment Performance Report for shortages or discrepancies in accordance with the provisions of reference 4.C.

b. Pretest inspection procedures required by reference 4.M. to include the following:

- 1) Visual inspection for defects.
- 2) Removal of all preservatives.
- 3) Check for completeness of assembly.
- 4) Inclusion of maintenance support package.

6.2.1.2 Physical Characteristics

Determine the physical characteristics of the environmental control unit according to the procedures of reference 4.R. Photograph the equipment.

6.2.2. Installation Characteristics

Perform the applicable procedures of reference 4.S. and observe for the following:

- a. Ease of installation and removal.
- b. Equipment flexibility for arrangement and mounting.
- c. Accessibility for operation and maintenance.

6.2.3 Power Requirements

Determine the suitability of the power sources designated by QMR or SDR for operation of the environmental control unit (reference 4.Q. for electrical power).

6.2.4 Operational Performance

The operational performance of the environmental control unit shall be evaluated during ground operations, with and without engines running, if applicable, and during transient and steady state flight operations with aircraft flying at different altitudes and speeds within the limitations of the aircraft. The resultant evaluations shall be compared with the requirements and tolerances established by QMR, SDR, TC or other approved documents.

a. Ground Operation - Engines Off

Exercise all manually operated controls to determine ease of movement and resultant equipment responses.

b. Ground Operation - Engines On

- 1) Exercise all controls for manually operated units and manual overrides for automatic units to determine ease of operation and resultant responses of the system.
- 2) Adjust manual systems to provide environmental conditions within stated requirements and tolerances and/or evaluate the capability of automatic systems to operate within the stated requirements and tolerances. Determine the range of temperature change, rate of flow and pressurization.
- 3) Determine the extent to which transparent areas are fogged or frosted by entrained moisture resulting from operation of the environmental control unit.
- 4) Determine if contaminants are introduced into compartment air as a result of operation of the environmental control unit.

c. Flight Operation

Operate the environmental control unit during all allowable phases of transient flight (climb, dive, landing, acceleration) and steady state flight (include minimum and maximum speeds at low and high altitudes). Perform the procedures of paragraph 6.2.4 b. 1) through 4) above.

6.2.5 Compatibility with Related Equipment

Perform applicable sections of reference 4.W. to determine any lack of electrical and mechanical compatibility that may exist between

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environmental control units and aircraft equipment with which they are required to operate.

6.2.6 Durability

Throughout the entire service testing period, monitor the durability of the environmental control unit in accordance with the applicable procedures of reference 4.O.

6.2.7 Effects of Weather

Throughout the entire period of service testing, operate the environmental control unit under all conditions of existing weather as described in the procedures of reference 4.P.

6.2.8 Maintenance Evaluation

Perform the maintenance requirements as detailed in references 4.H. and 4.U. Utilize personnel possessing the appropriate MOS and skill levels; tools and test equipment, technical manuals, and repair parts for the prescribed level of maintenance. Log all maintenance actions required for retaining equipment in, or restoring it to, specified conditions of the Maintenance Analysis Chart described in reference 4.H.

a. Tools and Test Equipment

Throughout the conduct of the service test, evaluate the use of common and special tools and test equipment to determine whether they are suitable and needed for the intended purpose and prescribed maintenance level. Perform the applicable procedures of reference 4.H. and 4.U. Log all relevant findings in the Special Tool Analysis Chart described in reference 4.H.

b. Technical Manuals

Evaluate the adequacy and simplicity of the equipment technical manuals for their intended maintenance levels as specified in references 4.H. and 4.Y. Log all pertinent data and comments in the Maintenance Package Literature Chart described in reference 4.H.

c. Repair Parts

Evaluate the adequacy and quantity of repair parts provided for all levels of maintenance in accordance with the procedures of references 4.H. and 4.U. Log all pertinent data and comments in the Parts Analysis Chart described in reference 4.H.

6.2.9 Maintainability

Throughout the entire period of service testing, assess the maintainability characteristics of the environmental control unit in accordance with reference 4.H. and evaluate the following:

- a. Whether the system meets the maintainability design requirements specified by QMR, SDR, TC, or other established criteria.
- b. Whether the time required for individual maintenance operations is considered excessive based on previous experience with similar equipment.
- c. The ease of access to facilitate inspection, test, repair and replacement.
- d. The maximum utilization of interchangeable components.
- e. The maximum utilization of common tools for maintenance operations.
- f. Whether major components are designed for removal as individual units.
- g. The existence of conditions which will adversely affect the conduct of maintenance operations or generate excessive maintenance requirements.

6.2.10 Reliability

Beginning with the initial checkout of the environmental control unit, assess the reliability characteristics of the system in accordance with reference 4.V. Make maximum use of the data collected and logged on the special analysis charts used in evaluating the maintenance test package as described in reference 4.H.

6.2.11 Achieved Availability.

To evaluate the achieved availability of the environmental control unit, ensure that sufficient data is logged on the special analysis charts described in paragraph 6.2.8 to be able to determine the two factors, mean-time-between-maintenance (MTBM) and mean active maintenance downtime (\bar{M}), resulting from both preventive and corrective maintenance actions. At the completion of service testing, extract and summarize this data and compute achieved availability (A_a) using the following formula:

$$A_a = \frac{MTBM}{MTBM + \bar{M}} \quad (\text{references 4.H. and 4.U})$$

6.2.12 Safety

- a. Throughout the conduct of all testing as outlined in this MTP, monitor all safety aspects associated with environmental control units in accordance with reference 4.T.

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b. Provide safety confirmation in accordance with the provisions of reference 4.F.

c. In addition to data required by reference 4.T., record comments concerning the following:

- 1) Analysis to establish that no identifiable hazards are present during testing or operation of environmental control units.
- 2) Inspection for high voltage hazard control and adequacy of protective devices to include interlocks and warning plates.
- 3) Evaluation of any hazards, including radiological hazards, associated with the operation and maintenance of environmental control units.

6.2.13 Human Factors Evaluation

a. Throughout testing, monitor and appraise human factors to identify design or operational features conducive to error and delay in mission accomplishment by user personnel in accordance with the procedures given in reference 4.X.

b. Prepare checklist for all tasks associated with all phases of operation and maintenance. These checklists shall be used to rate each task as satisfactory or unsatisfactory; include the following:

- 1) Communications quality of instructions as indicated by the ease of understanding technical manuals.
- 2) System design to the extent of personnel compatibility with instrument arrangement, controls, etc.
- 3) Minimum and optimum number of personnel for each action and the skill level(s) required.
- 4) Time(s) required.

6.2.14 Personnel Training Requirements

a. Throughout the testing, monitor and evaluate all operator and organizational maintenance personnel training requirements in accordance with reference 4.N.

b. In addition to the data required by reference 4.N., record narrative comments concerning the following training factors:

- 1) Scope and effectiveness of pretest training.
- 2) Need for additional training in the same or different fields.

6.3 TEST DATA

6.3.1 Preparation for Test

Data to be recorded prior to testing shall include, as a minimum, the following:

a. Nomenclature, serial number(s), manufacturer's name, and function of the item(s), accuracy tolerances, calibration requirements, and last date calibrated of the test equipment.

b. Damages incurred during installation and/or manufacturing.

6.3.2 Test Conduct

a. Data originating in all tests and phases shall be recorded in the following forms, as appropriate.

- 1) Operators', observers', and test controllers' records, questionnaires, etc.
- 2) Narrative comments and observations.
- 3) Maintenance records.
- 4) Photographs; still and movie.
- 5) Diagrams and sketches.

b. All data items shall be properly identified and annotated with respect to --

- 1) Test, subtest, test phase.
- 2) Source.
- 3) Time.
- 4) Pertinent correlative information.

c. Data to be recorded in addition to specific instructions given in succeeding paragraphs for each subtest shall include:

- 1) Sample size (number of measurement repetitions).
- 2) Instrument or measurement system mean error stated accuracy.

6.3.2.1 Initial Inspection

6.3.2.1.1 Inventory Check and Visual Inspection -

Record the following:

- a. Evidence of damage incurred prior to receipt.
- b. Exterior identification markings of the shipment in accordance with reference 4.I or other governing documents.
- c. Interior markings of shipment in accordance with reference 4.J or other governing documents.

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d. Physical condition.

e. The completeness of the shipment when items are compared against the BIIL. Also, indicate the existence of materiel discrepancies in the shipment and the number of EPRs which were prepared.

6.3.2.1.2 Physical Characteristics -

a. Record the physical characteristics of each major unit of the environmental control unit according to the procedures of reference 4.R.

b. Identify and retain all photographs taken.

6.3.2.2 Installation Characteristics

Record the data required by reference 4.S. including comments on the following:

a. Ease of installation and removal.

b. Equipment flexibility for arrangement and mounting.

c. Accessibility for operation and maintenance.

6.3.2.3 Power Requirements

Record data required by QMR or SDR and reference 4.Q.

6.3.2.4 Operational Performance

Record the following:

a. Ground Operation - Engines Off

Comments on the ease of movement and equipment response relative to manually operated controls.

b. Ground Operation - Engines On

- 1) Comments on ease of operation and resultant response to system controls.
- 2) Temperature, rate of flow and pressurization measurements.
- 3) Degree of frosting or fogging of transparent areas.
- 4) Percentage of contaminants in compartment air.

c. Flight Operations

Data of paragraph 6.3.2.4 b. 1) through 4).

6.3.2.5 Compatibility with Related Equipment

Record data required by reference 4.W.

6.3.2.6 Durability

Record data requirements of reference 4.O.

6.3.2.7 Effects of Weather

Record data required by applicable procedures of reference 4.P.

6.3.2.8 Maintenance Evaluation

Record data required by references 4.H and 4.U. and complete the following forms:

- a. Maintenance Analysis Chart
- b. Special Tool and Equipment Chart
- c. Maintenance Package Literature Chart
- d. Parts Analysis Chart

6.3.2.9 Maintainability

Record applicable requirements of reference 4.H. and comments on the following:

- a. Degree of accomplishment of the maintainability design requirements of the QMR, SDR, TC, or other established criteria.
- b. Maintenance time required as compared to previous experience on similar equipment.
- c. Ease of access for inspection, test, repair and replacement.
- d. Utilization of interchangeable components.
- e. Utilization of common tools for maintenance.
- f. Design of major components for removal as individual units.
- g. Conditions which will adversely affect maintenance operations.

6.3.2.10 Reliability

Record data required by reference 4.V.

6.3.2.11 Achieved Availability

Record the following:

- a. Mean-time-between-maintenance (MTEM).
- b. Mean active maintenance downtime (\bar{M}).
- c. Calculated value of A_a .

6.3.2.12 Safety

Record the following:

- a. Data in accordance with reference 4.T.
- b. Comments concerning safety confirmation.
- c. Analysis of identifiable hazards associated with the operation of the equipment.
- d. Results of inspection of high voltage hazard control.
- e. Evaluation of possible hazards, including radiological, associated with the operation and maintenance of the equipment.

6.3.2.13 Human Factors Evaluation

Record the following:

- a. Data in accordance with reference 4.X.
- b. Test phases on motion picture film.
- c. Times of accomplishment of phases in hours and minutes.
- d. Comments pertaining to the capability of average trained operator and maintenance personnel to operate and maintain environmental control units.

6.3.2.14 Personnel Training Requirements

- a. Record data in accordance with reference 4.N.
- b. Record comments concerning the scope and effectiveness of pretest training and any needs for additional training.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Data Reduction

Processing of raw data shall, in general, consist of organizing, marking for identification and correlation, and grouping the test data according to subtest title. Test criteria or specifications shall be noted on the test data presentation to facilitate analysis and comparison. Where necessary, test data measurement units shall be converted to be compatible with units given by test criteria or specifications.

6.4.2 Data Presentation

Presentation of test results shall consist of --

a. A composite documentation of the reduced and correlated data arranged by test phases in the general form of narrative description supported by diagrams, photographs, graphs, and tabular data. Mission aspects to be made clearly evident are the degree to which the environmental control unit provides conditions under which aircraft can be safely and efficiently operated.

b. Supplements or annexes to the basic document, delineating the common service test factors which are of sufficient scope, importance and/or complexity to warrant separate treatment. Each supplement shall include the applicable supporting data.

c. A further analysis to determine the extent to which the environmental control unit under test exceeds the performance characteristics or otherwise provides distinct advantages over existing Army equipment providing the same requirements.

d. Recommendations as to the suitability of the environmental control unit and its maintenance test package for use by the Army.

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13. ABSTRACT Procedures are described for evaluating aircraft ventilation, heating, moisture and contamination control, cooling and heating equipment or any combination of these systems. The evaluation is described under simulated tactical conditions.			

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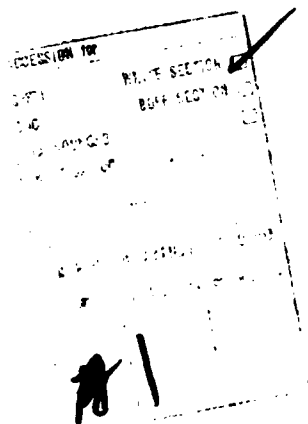
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